Security primitives II

Secure channel

Secure storage

…

PA193 – Secure coding

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Security primitives

- Secure channel
  - Communication
- Secure envelope
  - Data protection
- Secure storage
  - Storage
- Use standard, commonly used mechanisms
  - It is very difficult to create your own mechanisms that will be as secure as the standard ones

Secure channel

- secure channel is a way of transferring data that is resistant to overhearing and tampering

Source: Wikipedia

- Examples
  - Secure Messaging (smartcards)
    - ISO 7816-4
    - Open Platform / Global Platform
  - SSL/TLS
  - IPSEC
  - VPN

Secure channel

- Authentication of parties
- Confidentiality of data
- Integrity of data

- Based on:
  - Symmetric crypto
    - E.g. encryption + MAC, 4 symmetric keys shared
      - 2 for each direction
  - Asymmetric crypto

Case study SSL/TLS

- Let’s look at the failure of SSL/TLS in more details
  - Read more at:
    - http://www.ieee-security.org/TC/SP2013/papers/4977a511.pdf
- Basic knowledge of SSL/TLS expected
  - Mandatory server authentication
  - Optional client authentication
  - Authentication based on X.509 certs and private key
  - PKI infrastructure to validate certs needed
  - Confidentiality and integrity provided
  - Non-repudiation not provided

Weaknesses in Crypto Primitives

- SSL/TLS started with 40/56 bit symmetric keys
- DES, RC2, RC4
- US export regulation
- Slow changes, backward compatibility
- Still possible to see certs with unsecure parameters
  - Based on RSA-512 (!)
    - By the way Google was using RSA-1024 until Nov 2013
  - Based on md5
    - Collision attack on certs demonstrated

PRNG problems

- Netscape browser prior 1.22 relied on PRNG generating weak keys
- Debian problems with OpenSSL
- …

Remote timing attacks

- Against SSL servers using optimized RSA decryption based on OpenSSL
  - And that optimized decryption was default in OpenSSL prior 0.9.7b
- the long term secret of the server was leaking during the SSL/TLS handshake

Protocol attacks

- Ciphersuite downgrade
  - In SSL 2.0
- SSL Version downgrade
  - If clients misinterpret higher version error and try to continue with a lower protocol version
- Renegotiation attack
  - Renegotiate security related parameters

Trust model - X.509 Certificates

- Hostname Validation
  - Do not skip the hostname validation
  - Study: over 1000 out of 13500 Android applications do not validate the hostname
  - Read more at:
    - http://www2.dcsec.uni-hannover.de/files/android/p50-fahl.pdf
  - [Analysis of Android SSL (in)security]
- Parsing attacks
  - Binary 0 in CN
  - Something.com0other.com

Trust model - X.509 Certificates

- Anchoring trust
  - Web browsers include +-150 trust points from +-50 organizations
    - CA Compromise (DigiNotar)
    - The power of goverments over CAs
    - Transitivity of trust (basicConstrains – CA:TRUE)
      - This flag must be checked otherwise anybody could be validated as any web site
      - MS CryptoAPI did not
      - Apple iOS did not

Trust model - X.509 Certificates

- Revocation
  - Blocking the certificates
    - OCSP or CRL download

http vs. https

- Stripping TLS
  - relay https pages over http
- A tool called SSLstrip exists
  - a man-in-the-middle attack
- HTTP Strict Transport Security (HSTS)
  - web security policy mechanism where a web server declares that only secure HTTPS connections can be used.
  - the policy is communicated via a HTTP response header called "Strict-Transport-Security".

Secure storage: how to keep secrets secret

- Secret data
  - Symmetric encryption keys
  - Asymmetric Private keys
  - Passwords
  - …
- Storing secrets in SW
  - Completely securely – IMPOSSIBLE
    - Debugging
    - Paging memory to files
    - Malicious administrators
    - …
- Storing secrets in HW (HSM, Smartcards, …)

Secure storage

- MS Windows: **Data Protection API (DPAPI)**
- Mac OS X: **Keychain Services API**
- Linux GNOME: **gnome-keyring-manager**
- Linux KDE: **kwallet**

Need to store secrets?

- Password hashing
  - Crypt (old)
  - Md5 (old)
  - Sha1,2
- Salting
  - Attackers cannot store pre-computed hash values
  - 64 bit salt means that an attacker would have to potentially prepare 2^{64} more hash values

Deriving keys from passwords

- Make it slow
  - Avoid dictionary attacks!
- PKCS#5
  - Password-Based Key Derivation Function #1 (PBKDF1)
  - Password-Based Key Derivation Function #2 (PBKDF2)
  - Hash the password 100x – 1000x
- In MS Crypto API use CryptDeriveKey
  - With similar functionality

[CryptoWorld 11-12/2013]

Protecting secrets in Windows

- Data Protection API (DPAPI)
  - CryptProtectData, CryptUnprotectData
- Data available to user
  - Bound with user account, available on multiple machines but not on other accounts
- Data available to machine
  - Available to any user at the machine, not available at other machines
  - Use CRYPTPROTECT_LOCAL_MACHINE flag

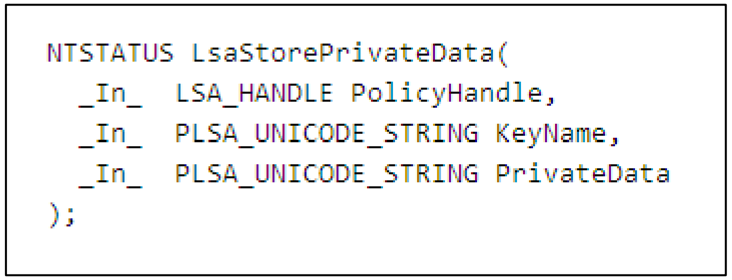
Protecting secrets on Windows

- DAPI does not provide storage (only encryption/decryption)
- You have to manage storage yourself
  - Be careful to protect the encrypted data with correct ACLs in files/registry

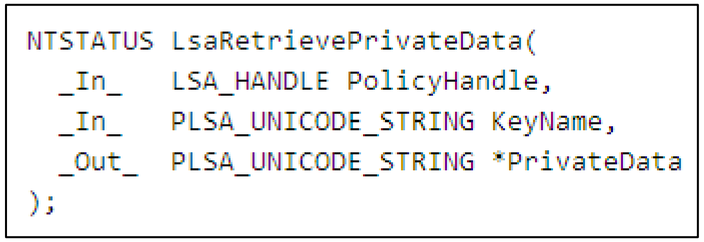
- Any application running on the USER can decrypt the secrets!
- If you do not like this, use pOptionalEntropy field
  - To protect your secrets with another secret ☺

LSA interface (old stuff)

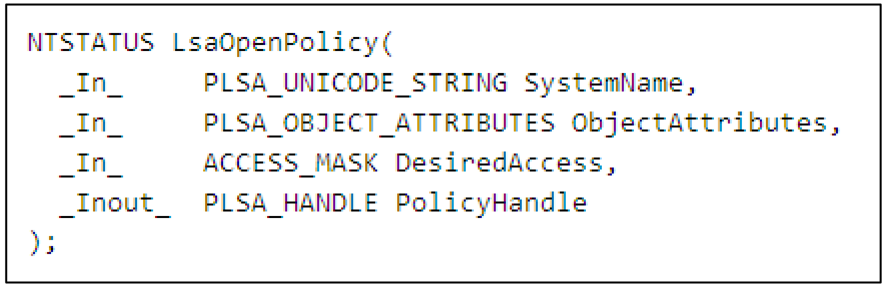
- “The Local Security Authority (LSA) is a protected subsystem of Windows that maintains information about all aspects of local security on a system.”
- LSA secrets:



```
NTSTATUS LsaStorePrivateData(
  _In_  LSA_HANDLE PolicyHandle,
  _In_  PLSA_UNICODE_STRING KeyName,
  _In_  PLSA_UNICODE_STRING PrivateData
);
```



```
NTSTATUS LsaRetrievePrivateData(
  _In_    LSA_HANDLE PolicyHandle,
  _In_    PLSA_UNICODE_STRING KeyName,
  _Out_   PLSA_UNICODE_STRING *PrivateData
);
```

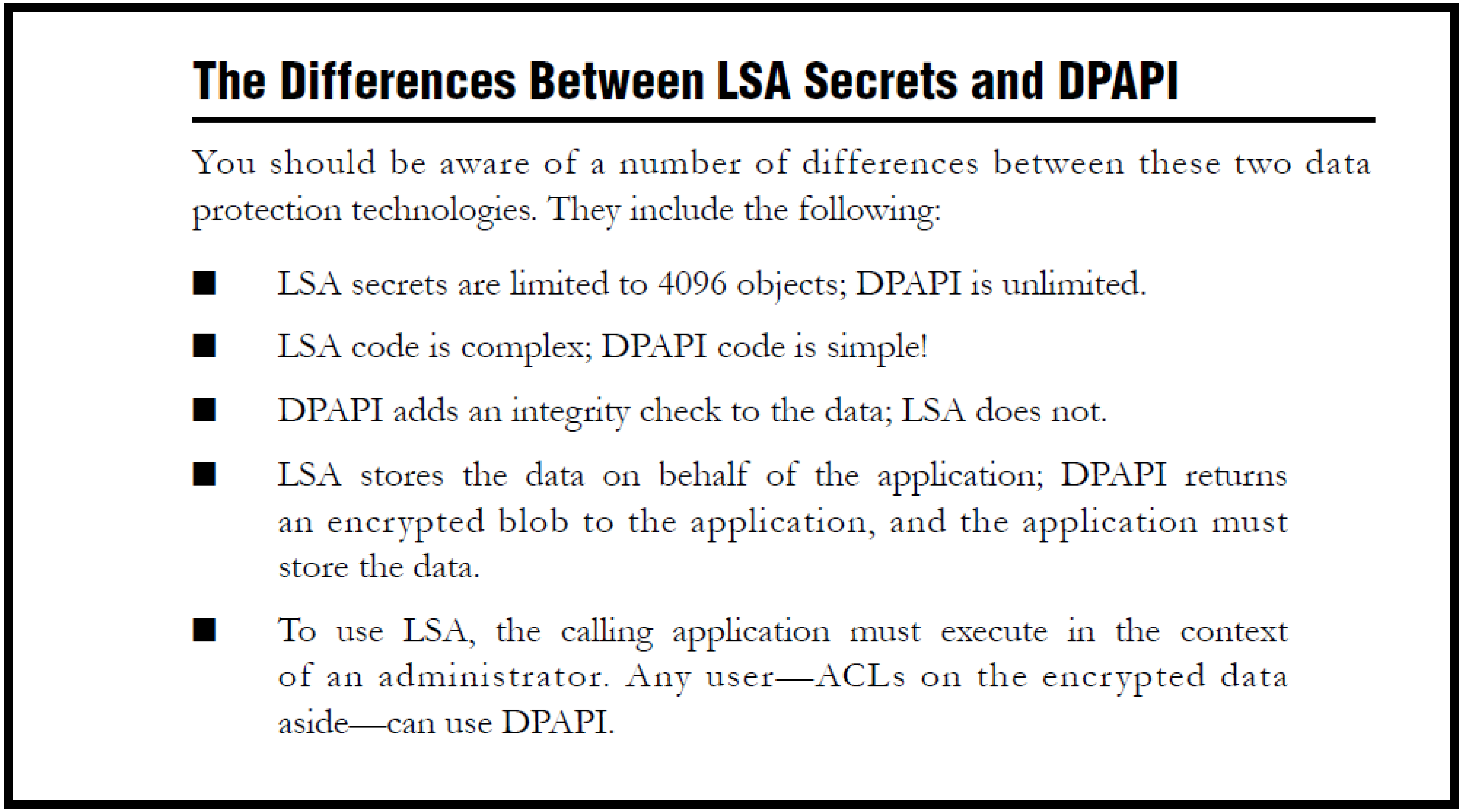


```
NTSTATUS LsaOpenPolicy(
  _In_      PLSA_UNICODE_STRING SystemName,
  _In_      PLSA_OBJECT_ATTRIBUTES ObjectAttributes,
  _In_      ACCESS_MASK DesiredAccess,
  _Inout_   PLSA_HANDLE PolicyHandle
);
```

LSA interface

- LSA secrets:
  - Local data
    - Can be read only at the machine storing data (L$)
  - Global data
    - Created on domain controller and replicated (G$)
  - Machine data
    - Can be accessed only by OS (M$)
  - Private data
    - Can be used by your application

LSA vs. DPAPI



The Differences Between LSA Secrets and DPAPI

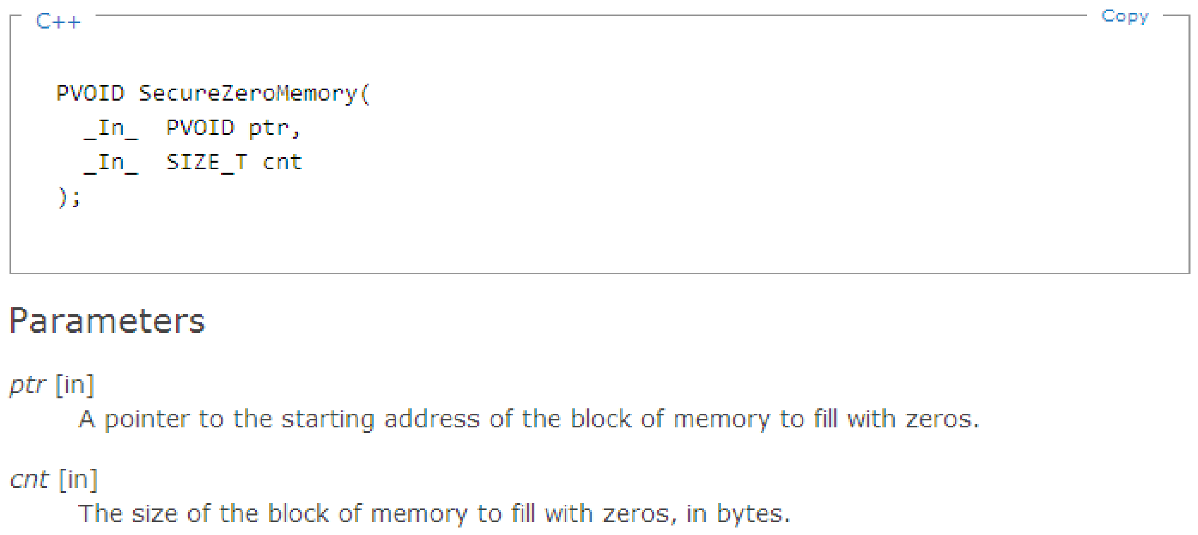
You should be aware of a number of differences between these two data protection technologies. They include the following:

- LSA secrets are limited to 4096 objects; DPAPI is unlimited.
- LSA code is complex; DPAPI code is simple!
- DPAPI adds an integrity check to the data; LSA does not.
- LSA stores the data on behalf of the application; DPAPI returns an encrypted blob to the application, and the application must store the data.
- To use LSA, the calling application must execute in the context of an administrator. Any user—ACLs on the encrypted data aside—can use DPAPI.

Source: Writing secure code, 2nd edition

Managing secrets in memory

- ZeroMemory()
  - Macro using memset
- Compiler optimizations can remove the call of the function!!!
- Use SecureZeroMemory() instead



```
PVOID SecureZeroMemory(
  _In_  PVOID ptr,
  _In_  SIZE_T cnt
);
```

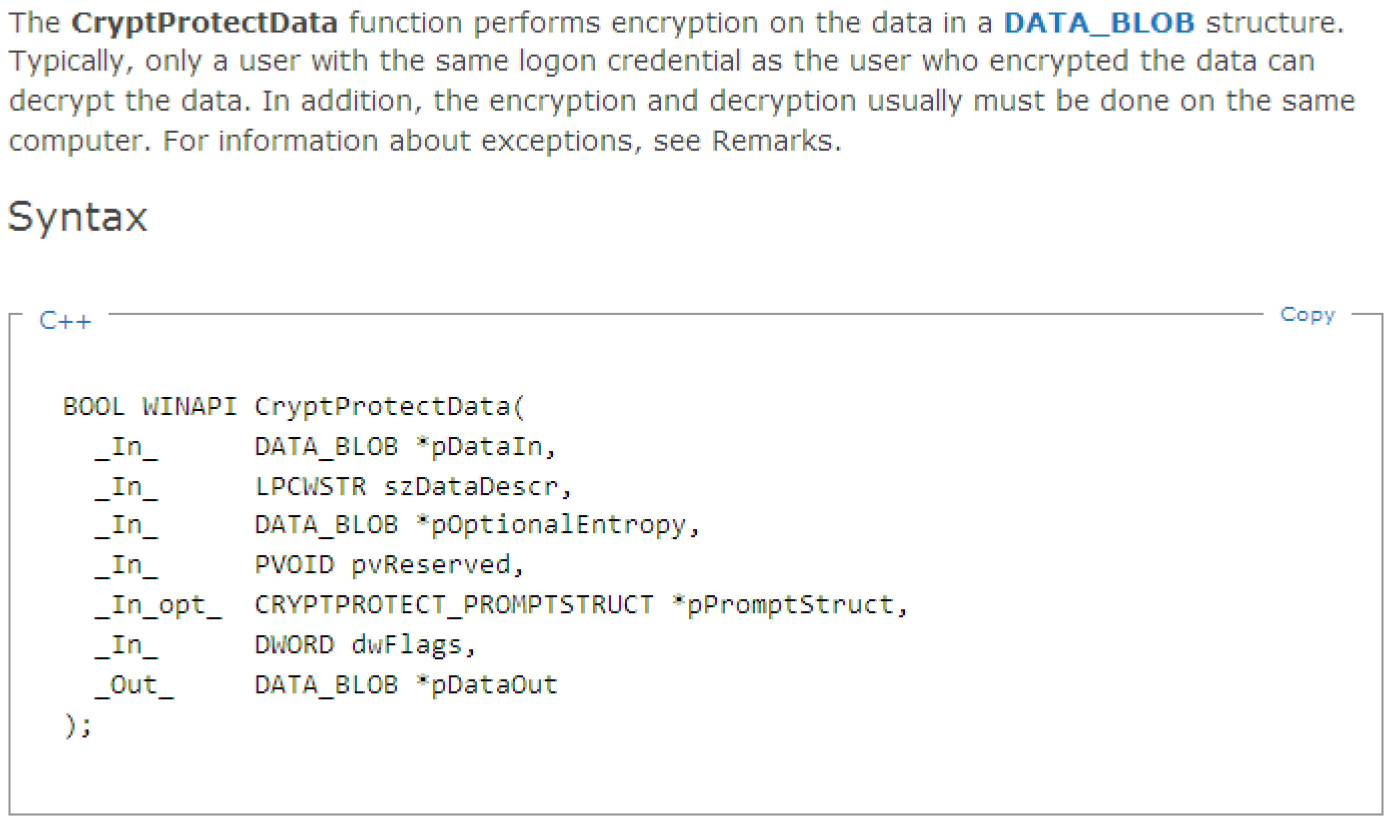
Parameters

ptr [in]
A pointer to the starting address of the block of memory to fill with zeros.

cnt [in]
The size of the block of memory to fill with zeros, in bytes.

Managing secrets in Memory

- CryptProtectMemory() and CryptUnprotectMemory()


The **CryptProtectData** function performs encryption on the data in a **DATA_BLOB** structure. Typically, only a user with the same logon credential as the user who encrypted the data can decrypt the data. In addition, the encryption and decryption usually must be done on the same computer. For information about exceptions, see Remarks.

Syntax

C++ Copy

```
BOOL WINAPI CryptProtectData(
  _In_      DATA_BLOB *pDataIn,
  _In_      LPCWSTR szDataDescr,
  _In_      DATA_BLOB *pOptionalEntropy,
  _In_      PVOID pvReserved,
  _In_opt_  CRYPTPROTECT_PROMPTSTRUCT *pPromptStruct,
  _In_      DWORD dwFlags,
  _Out_     DATA_BLOB *pDataOut
);
```

Source: MSDN

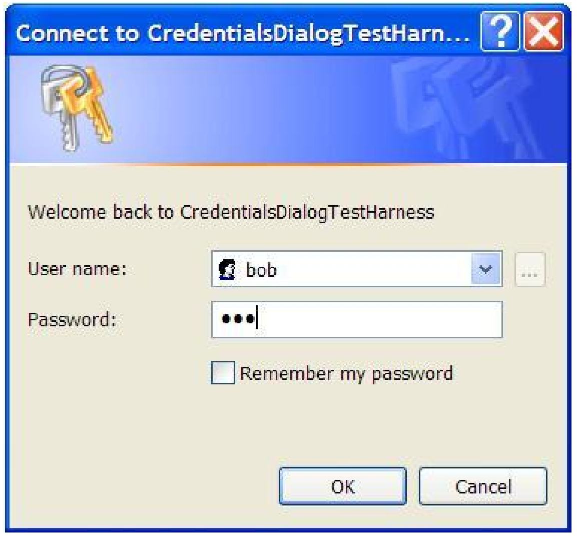
Locking Memory to Prevent Paging

- To keep your sensitive data in memory only (and not in a paging file)
- Affects performance
- Does not prevent dumping memory to disk when hibernating (or crash dump file)
- Does not prevent a debugger to read the memory
- Lock memory before storing the secrets in the memory
- VirtualLock()
- AllocateUserPhysicalPages()

CROCS

Windows credentials manager

- Asking the user for credentials
- CredUIPromptForCredentials()
- CredUIPromptForWindowsCredentials()
  - From Vista up



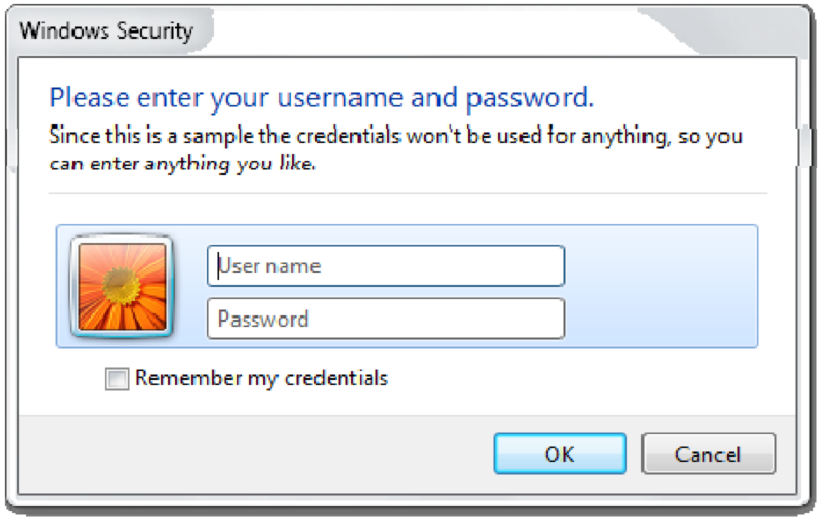
Connect to CredentialsDialogTestHarn...

Welcome back to CredentialsDialogTestHarness

User name: bob

Password: •••

☐ Remember my password



Windows Security

Please enter your username and password.

Since this is a sample the credentials won't be used for anything, so you can enter anything you like.

User name

Password

☐ Remember my credentials

Protect data

- For secret keys use
  - Pkcs#8
  - Pkcs#12 (pfx)
- For digital signatures use
  - CMS (PKCS#7)
  - Secure email
    - S/MIME
      - Based on X.509 certificates
      - Transparent vs. opaque signing
    - PGP

PKCS#8

- Format for storing private key
- Independent on private key algorithm
- Key can be encrypted
- File suffix “.pkcs8”

```
PrivateKeyInfo ::= SEQUENCE {
   version Version,
   privateKeyAlgorithm AlgorithmIdentifier {{PrivateKeyAlgorithms}},
   privateKey PrivateKey,
   attributes [0] Attributes OPTIONAL }
```

PKCS#12

- Collection of cryptographic objects
- Privacy/confidentiality
  - Public key privacy mode: encrypted by a public key
  - Password privacy mode: encrypted by a symmetric key derived from username and password
- Integrity modes
  - Public key integrity mode: digital signature
  - Password protection mode: MAC based on password
- File suffix “.p12”, “.pfx”.

PKCS#12

- “SafeContents” is made up of “SafeBags”
- SafeBag types:
  - KeyBag: PKCS#8 private key
  - PKCS8ShroudedKeyBag: private key, which has been shrouded (encrypted) in accordance with PKCS #8
  - CertBag: certificate (X.509, SDSI – Simple Distributed Security Infrastructure)
  - CRLBag: CRL (X.509)
  - SecretBag: any other secret of a user

PKCS#7 / CMS

- Encapsulated content
- Content types:
  - Data (any plaintext)
  - Signed Data (digital signature based on X.509 certs)
  - Enveloped Data (encrypted data)
    - key transport: symmetric key encrypted by the recipient's public key;
    - key agreement: pairwise symmetric key created using the recipient's public key and the sender's private key
    - symmetric key-encryption keys: using a previously distributed key
    - passwords: key is derived from a password
  - Authenticated data (MAC + MAC key)